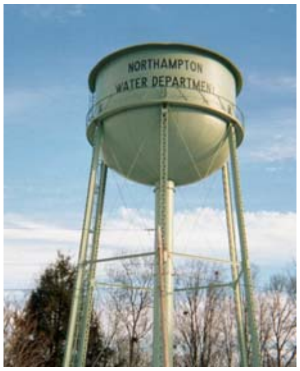
CITY of NORTHAMPTON

WATER SYSTEM



MASTER PLAN UPDATE

Prepared for:
The City of Northampton
Board of Public Works
By Dewberry, Inc.
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TABLE OF CONTENTS

LIST OF TABLES PAGE

SECTION I – INTRODUCTION

In April 2004, the City of Northampton contracted with Dewberry-Goodkind, Inc. (Dewberry) to update the City's existing WaterCAD Hydraulic Model and evaluate the Turkey Hill Tank and related system improvements. These two tasks lent themselves to updating the City's Water System Master Plan, which was previously completed in 1989. Dewberry has completed this update and the results of this task are presented in this report

GOAL OF THE REPORT:

The goal of this report is to provide the City with the information necessary to implement a phased program of improvements to its water system for a 20 year planning period by:

- ***Determining the adequacy of the City's existing water system to meet present and projected domestic water demands; and***

- ***Determining the Water System's ability to deliver required fire flows at adequate pressures.***

To achieve these goals, Dewberry:

- Utilized an updated computer model to analyze and evaluate the City's existing water system under various scenarios and demand conditions, including fire flows; evaluated options to address immediate and future system deficiencies;

- Developed a prioritized plan of recommended improvements to eliminate these system deficiencies and

- Developed cost estimates for each recommended improvement.

Scope of Work:

1. ***Review the water demand and population projections estimated in the 1989 Master Plan and update the data for the next 20-year planning period using historical water consumption data available from the City and the Regional Planning Commission.***

2. ***Review system fire flow requirements estimated in the 1989 Master Plan and revise data as necessary utilizing historical Insurance Services Offices data, industry standards for fire protection and information provided by City officials such as the Fire Chief.***

3. ***Impose updated present and future water demands on the calibrated model to determine deficiencies in the distribution system during normal day-time demands, peak-hour demands, night-time demands for refilling storage tanks, and maximum-day demands with fire flows.***

4. ***Conduct computer simulations using the calibrated model to evaluate alternatives to improve the water distribution system and alleviate deficiencies previously identified to meet both current and future water needs with respect to water supply, system storage, and fire protection. This task will be a collaborative effort with the City to ensure that all known concerns are addressed and that the necessary information to develop practical recommendations for improving the water distribution system is obtained.***

5. ***Evaluate the adequacy of the existing water supply, distribution system and storage facilities to meet future water demand requirements through the Year 2025.***

6. ***Review the recommended improvements from the 1989 Master Plan with respect to the City's water supply, distribution system and storage. Update and/or develop alternative recommendations for the City to improve its water supply, distribution system and storage, to alleviate deficiencies identified during the completion of the hydraulic analysis and to meet present and future water demands through the Year 2025.***

7. ***Develop recommendations to improve the existing operation and maintenance of the City's water supply, storage and, distribution systems, to continue to meet water demands through the year 2025.***

8. ***Prepare cost estimates associated with the recommended improvements to the City's water supply, storage, and distribution systems.***

9. ***Prepare a prioritized, 20-year phased capital improvement program for the City to implement the recommended improvements to its water supply and distribution systems through the Year 2025. This program will be coordinated with the City's fiscal budget.***

SECTION II – WATER SYSTEM DEMANDS

GENERAL

Water usage projections are utilized to assess the impact of future increases in water demands on the supply, storage and distribution components of a system. The adequacy of a water system to meet future water consumption needs is determinined by evaluating historic water consumption data and projecting future system needs. This analysis establishes water usage trends which are then used to estimate future water consumption based on population projections. The following section presents an analysis of historic water consumption information and future water demands based upon projected population and water usage through the study period of 2025.

POPULATION PROJECTIONS

In order to develop a population projection for this report, the past population data for the City of Northampton was reviewed. Past population figures for the last ten years, as reported by the City, are shown in Table 2-1. The data shows a stable population with an actual reduction of approximately 430 people over the last ten years.

TABLE 2-1
PAST POPULATION

Year	Population	Percent Change
1993	29,726	N/A
1994	29,503	-0.76
1995	29,823	+1.07
1996	29,800	-0.10
1997	29,739	-0.21
1998	29,816	+0.25
1999	29,365	-1.54
2000	29,978	+2.04
2001	29,907	-0.24
2002	29,175	-2.50
2003	29,287	+0.40
2004	29,287	+0.00

With respect to future growth, both the Massachusetts Institute for Social and Economic Research (MISER) and the U.S Census were contacted to assist in developing population projections for the City. MISER and the U.S. Census have published similar population projections for the City for the years 2010 and 2020 which are 29,118 and 29,136 persons, respectively. These estimates do not anticipate any growth occuring in the the City over the next 20 years.

According to the City's Office of Planning and Development, the Northampton State Hospital has completed the permitting process and is proceeding with a redevelopment plan that will span the next 15 years. Upon completion, as many as 300 residential units of varying size will be added on the Hospital's grounds along with approximately 450,000 square feet of commercial/retail space.

Two additional developments well on their way to completion include Rocky Hill, a 32 unit residential housing development, and Ice Pond, a 26 unit residential housing development. Both are located near the intersection of Florence Road and Westhampton Road. The Oaks development on Burts Pit Road, is another subdivision under construction, that must be considered in determining the City's future water demand. Construction has just begun on this development and, upon completion, will include 64 residential housing units. Of these 64, 12 will be on private wells due to fact that they are above an elevation of 320 feet.

In regard to future construction, the Office of Planning and Development has mentioned several potential projects. The first is Bear Hill, a 55 year-old plus community housing development will be comprised of 55 condominium type one and two floor units. This project is expected to enter the construction phase in the near future. The second is Kensington Estates, a 12-15 unit residential housing development located on Glendale Road. The developer is currently awaiting a decision by the City as to whether the development will be supplied with City water or will require the installation of private wells. The third is a 50 unit residential housing development, under consideration, located near the intersection of Burts Pit Road and Florence Road.

Based on data published by MISER, for the year 2000, the average number of people per household in the City of Northampton was 2.4. Assuming that the noted developments above are completed within the study period to the extent planned, the City would experience an increase of approximately 500 residential units and approximately 1,200 residents by 2025. Based on current population figures, this would result in an overall growth of four percent. There are other parcels of land available within the City which could support similar sized residential developments in the future.

Considering the number of housing units currently planned to be completed, along with the potential for additional residential developments to be completed within the study period, we have projected a six percent total increase in the City's population to the year 2025. This estimate results in a total population of approximately 31,044 people. A summary of the projected population data is shown in Table 2-2. This percentage increase in poplation will be used to project the future residential water demands as presented in the following section.

TABLE 2-2
POPULATION PROJECTIONS

Year	Projected Population
2005(1)	29,287
2010	29,726
2015	30,165
2020	30,605
2025	31,044

(1) Year 2004 population of 29,287 assumed for year 2005.

WATER DEMAND PROJECTIONS

Average Day Demands

Average day demands are commonly defined as the total water supplied in one year divided by 365 days, expressed in millions of gallons per day (MGD). It includes water used for residential, agricultural, commercial, and industrial consumption, as well as unaccounted-for water. Historical average day water consumption data for the City of Northampton was obtained from City records for years 1996 through 2004 and are presented in Table 2-3.

TABLE 2-3
HISTORICAL AVERAGE DAY DEMAND BY USER CLASSIFICATION

Year	Residential Demand (MGD)	Commercial Demand (MGD)	Industrial/ Agricultural Demand (MGD)	Other [1] Demand (MGD)	Unaccounted-For Demand (MGD)	Total Average Day Demand (MGD)
1996	3.22	0.16	0.04	0.02	0.19	3.64
1997	3.22	0.16	0.03	0.02	0.19	3.64
1998	3.25	0.17	0.04	0.02	0.19	3.67
1999	3.39	0.17	0.04	0.02	0.20	3.83
2000	3.24	0.16	0.04	0.02	0.19	3.66
2001	1.67	0.19	1.30	0.32	0.24	3.72
2002	1.62	0.22	1.25	0.09	0.19	3.37
2003	1.54	0.21	1.18	0.15	0.12	3.20
2004	1.55	0.21	1.19	0.15	0.12	3.22

(1) The user classification “Other” includes municipal, system flushing and miscellaneous usages.

As shown above, in Table 2-3, the total average day demand has decreased from the reported 1996 value of 3.64 MGD to the reported 2004 value of 3.22 MGD. The most significant reduction was from the year 2001 to 2002 which can be attributed to a decrease in population, and also an increase in water conservation due to a drought condition that occurred during this period.

Table 2-3, also shows a considerable shift in residential, agricultural and industrial demand usages that occurred after 2000 which can be attributed to changes in the accounting for the residential, agricultural and industrial user classifications.

A review of historical records from 2000 to 2004 indicates:

- That the combined industrial and agricultural water usage has remained relatively consistent at approximately thirty-seven percent of the total average day demand;

- Commercial water usage has also remained quite constant over the same period comprising approximately seven percent of the total average day demand.

Since 2000, the demands for the individal user classifications have been relatively stable with the combined agricultural and industrial usage making up approximately thirty-seven percent of the total average day demand, commercial usage making up approximately seven percent, and residential usage making up approximately forty-eight percent. The remaining percentage of usage includes municipal, system flushing, miscellaneous and unaccounted-for water usages.

The Northampton Water Department maintains individual meter reading records for all residential, agricultural, industrial, and commercial water users in the City.

Unaccounted for Water

Unaccounted-for water within the system typically consists of water used for street cleaning, hydrant flushing, leakage from the system, meter losses, and firefighting.

The reported percentage of unaccounted-for water from 1996 to 2002 (inclusive) has been in the range of 5 to 6.5 percent of the total water supplied and dropped to 3.7 percent of the total water supplied to the system in 2003 and 2004. These percentages are considered very good when compared to the generally accepted water works industry standard of 15 to 20 percent.

The City has undergone measures to reduce its unaccounted-for water including the completion of a water audit to review record keeping and accounting methods, and the testing of large user and source revenue meters, in 1994 and the subsequent completion of a leak detection survey of the entire distribution system in 1995.

It is recommended that:

- *The City consider continuing its efforts to reduce its unaccounted-for water such as further leak detection efforts and customer meter replacement programs. This will be of a higher priority when treatment of the City's water supply is implemented, since the cost of water production per gallon will be higher.*

Historical Per Capita Day Water Consumption

The historical per capita day water consumption based on the noted approach of combining the "Residential" and "Other" demand usages is shown in Table 2-4. The average per capita day consumption for the years 1996 through 2001 was approximately 111 gallons per capita day (gpcd). The average per capita day consumption for the years 2000 through 2004 was approximately 91 gpcd. This reduction in per capita usages can be attributed to the previously noted accounting changes made by the City with respect to residential, agricultural, and industrial user classifications, and the water conservation methods implemented by the City to address the drought condition that occurred during this period.

TABLE 2-4
HISTORICAL PER CAPITA AVERAGE DAY DEMANDS

Year	Residential (MGD)	Other (MGD)	Total Daily Consumption (MGD)	Population Served	Per Capita Consumption (GPCD)
1996	3.22	0.02	3.24	29,800	108.7
1997	3.22	0.02	3.24	29,739	109.0
1998	3.25	0.02	3.27	29,816	109.7
1999	3.39	0.02	3.41	29,365	116.1
2000	3.24	0.02	3.26	28,907	112.5
2001	1.67	0.32	1.99	18,538(1)	107.3
2002	1.62	0.09	1.71	18,655(1)	91.7
2003	1.54	0.15	1.69	18,730(1)	90.2
2004	1.55	0.15	1.70	18,808(1)	90.4

(1) Based on number of residential service connections multiplied by 2.5.

Water Usage Calculation Notes:

- *Changes to the method of calculating per capita water consumption were made in 2001 based on DEP Policies with respect to the Water Management Act Program. These changes are reflected in Table 2-4.*

- *There are a number of residents in Northampton who have private wells, and are not connected to the City's water system. For this situation, where a public water system does not serve the entire commnunity, DEP allows such public water systems to calculate per capita water consumption based on dividing the residential daily usage by the number of residential service connections times a factor of 2.5 which represents the DEP standard number of users per service connection. Since the City falls within the noted category, calculations for per capita water consumption were adjusted according to the allowable method.*

- *The estimates for the years previous to 2001 considered all of the City's residents to be served by the water system which would tend to inflate the per capita consumption value as well.*

- *Public awareness of water conservation, for both economic and environmental reasons, has increased in recent years due in part to efforts by municipalities and regulatory agencies. For this reason, per capita water consumption should remain relatively constant over the next twenty years. Therefore, for the purposes of estimating future residential demands, we have assumed a value of 90 gpcd which will remain constant throughout the study period.*

Projected Residential Average Day Demands

To estimate future residential average day demands, a per capita day consumption based on past water usage data is first determined. This amount is then multiplied by the projected population served for a given year.

- *For the purposes of this report, municipal, system flushing and miscellaneous water usages, which were included as the user classification "Other" in Table 2-3 will be added to the residential water usage to estimate per capita water consumption.*

Based on previous population projections, the future residential average day demands for the study period have been estimated and are presented in Table 2-5. As shown in Table 2-5, we have applied the projected six-percent total growth in population to the current population served for 2004 of 18,808 (as calculated based on the number of resident service connections times the 2.5 DEP factor). This will provide a more consistent and accurate estimate of residential demands since it takes into consideration the fact that not all of the City's residents are connected to the water system.

TABLE 2-5
PROJECTED RESIDENTIAL AVERAGE DAY DEMANDS

Year	Projected Population Served(2)	Per Capita(1) Consumption (GPCD)	Projected Residential Demand (MGD)
2005	18,808	90	1.70
2010	19,090	90	1.72
2015	19,373	90	1.74
2020	19,655	90	1.77
2025	19,937	90	1.79

(1) Includes "Residential" and "Other" category demands.
(2) Based on applying projected growth to number of residential service connections multiplied by 2.5 DEP factor.

Estimating Projected System Water Supply Demands

To develop future water supply demand projections for the system, each component of the average day demand including residential, commercial, industrial, agricultural, miscellaneous, and unaccounted-for water usages is estimated through the study period.

As shown in Table 2-3, the unaccounted-for water usage over the past two years has been approximately four percent of the total average daily water demand. Based on the City's past efforts to address leak detection and the calibration of meters, and its on-going policies with respect to water conservation, it is assumed that the unaccounted-for water will remain constant throughout the study period at approximately five percent of the total water supplied.

Future commercial, industrial and agricultural average day demands will be estimated based on past trends, and unaccounted-for demands will be estimated as a direct percentage of the total residential, commercial, industrial and agricultural demands.

A major increase in industrial, agricultural and commercial demands is not anticipated to occur through the study period given the current economic conditions and the fact that no specific future developments are planned at this time. However, for the purposes of this report, we have estimated that the combined industrial and agricultural demands as well as the commercial demands will increase by approximately twenty-five percent of current demands by the year 2025. This will provide a conservative estimate for water supply planning and allow for some potential growth within the commercial and industrial zones of the City.

The future average day and maximum day demands estimated in this section will be used in the following sections to evaluate the adequacy of the existing water system to meet future needs, and to evaluate various improvements to the water system utilizing the City's computerized hydraulic model which was updated as part of this study.

Projected Total Average Day Demands

Based on the projected residential water usage, and the criteria established for industrial, agricultural, commercial, and unaccounted-for usages, the estimated total future average day demands are as presented in Table 2-6.

TABLE 2-6
PROJECTED TOTAL AVERAGE DAY DEMANDS

Year	Residential (MGD)	Commercial (MGD)	Agricultural/ Industrial (MGD)	Unaccounted-for (MGD)	Total (MGD)
2005	1.70	0.210	1.190	0.120	3.22
2010	1.72	0.223	1.264	0.160	3.37
2015	1.74	0.236	1.339	0.166	3.48
2020	1.77	0.249	1.413	0.172	3.60
2025	1.79	0.263	1.490	0.177	3.72

Estimating Maximum Day Demands

In determining the adequacy of the existing water distribution system, the available supply must be capable of meeting the projected maximum day demands of the system. Maximum day demand is defined as the highest one day demand which occurs during the year, and is commonly expressed as a percentage of the average day demand.

2001 Maximum Daily Demand
vs.
Permitted Daily Use &
Total Gallons Used for Year

- *Allowed:* **4.77** million gal/day
- *24 hr record 2001:* **5.34** million gal
- *Total use in 2001:* **1.35** billion gal

Historical Maximum Day Demands

Table 2-7 presents the reported historical maximum day water demands from 1996 through 2004. As shown, historical maximum day demands have varied from 125 to 162 percent of the average day demand, with an average maximum day/average day ratio of approximately 1.41.

TABLE 2-7
HISTORICAL MAXIMUM DAY DEMANDS

Year	Average Day Demand (MGD)	Maximum Day Demand (MGD)	Maximum/ Average Day Ratio
1996	3.63	4.53	1.25
1997	3.64	5.35	1.47
1998	3.67	5.95	1.62
1999	3.83	5.62	1.47
2000	3.66	4.65	1.27
2001	3.72	5.34	1.44
2002	3.37	4.83	1.43
2003	3.20	4.70	1.47
2004	3.22	4.13	1.28

Projected Maximum Day Demands

For the purposes of this study, a maximum day/average day ratio of 1.50 was used to provide a conservative estimate, and to ensure the City will be able to meet potentially high demand periods. Based on this ratio, future maximum day demands have been estimated as shown in Table 2-8.

TABLE 2-8
PROJECTED MAXIMUM DAY DEMANDS

Year	Projected Average Day Demand (MGD)	Projected Maximum Day Demand (MGD)
2005	3.22	4.83
2010	3.37	5.05
2015	3.48	5.22
2020	3.60	5.41
2025	3.72	5.58

Peak Hour Demands

Peak hour demands are the highest hourly demands that occur during a 24-hour period and generally occur in conjunction with the maximum day demand. Peak hour demands can vary anywhere from 1.5 to 6 times the average day demand, and therefore should be met through system storage. Consequently, peak hour demands are considered when evaluating the adequacy of system storage and the ability of system pipelines to deliver such demands.

Based on source meter records for the maximum day of usage from 2001 through 2004, the peak hour demand was calculated to be approximately 1.3 times the maximum day demand. For the purposes of this study, a peak hour demand/maximum day ratio of 1.50 was used to provide a conservative estimate for evaluating system storage and capacity, and to ensure the City will be able to meet potentially high demand periods. The impact of peak hour demands on system storage is discussed further in Section 3. The impact of peak hour demands on the distribution system with respect to pipeline capacities is discussed in Section 4.

SECTION III – WATER STORAGE REQUIREMENTS

GENERAL

Distribution storage is provided to:

- Meet peak demands of short duration;
- Minimize pressure fluctuations during periods of demand changes in the distribtuion system; and
- Furnish a reserve for fire fighting.

Storage may also serve to provide an emergency supply in case of temporary breakdown of pumping facilities or major transmission main failure.

Required volumes of storage, denoted as “usable”, are allocated at specific levels within a storage facility to ensure the storage volume will be available at a hydraulic gradient adequate for the intended purpose.

There are three components to consider when evaluating storage capacity:

The first is equalization storage. Equalization storage for meeting peak demands and hourly demand flucuations should be provided at the top portion of the tank. The second, fire storage is provided directly below. The third, emergency storage is a function of the system characteristics and is allocated based on the assessed risk and need.

EQUALIZATION -----------→

STORAGE LEVEL

FIRE ---------------------------→

STORAGE LEVEL

EMERGENCY---------------→

STORAGE LEVEL

Example of how three components may be located in a water storage tank

WATER STORAGE REQUIREMENTS

The following presents an analysis of the City's water storage requirements.

Equalization Storage

Equalization storage is required to meet water system demands in excess of delivery capabilities from pumping facilities. The volume of equalization storage needed depends on pump capacity, transmission delivery, distribution system capacity, and system demand characteristics.

Equalization storage can be determined by developing a diurnal demand curve for the system which identifies the duration of system demands in excess of maximum day demand and the storage volume needed.

From the hourly demands recorded for the 2004 maximum day demand event, equalization storage was calculated to be approximately 15 percent of the maximum day demand. Based on our experience in designing and evaluating water system storage, we have estimated the future equalization storage to be 20 percent of the maximum day demand projected for the system. Using 20 percent, will provide a conservative estimate for planning and minimize the need to operate pumping and/or treatment facilities above the maximum day demand for prolonged periods of time. This will be particularly evident when the new water filtration plant is in service.

The City's current water system is fed via gravity whereby the source reservoirs provide supply directly into the system. This provides a great amount of storage capacity for the City. With the construction of the water filtration plant, this large source of storage will be reduced.

Table 2-8, projected the City's maximum day demand for the year 2025 to be 5.58 MGD. Applying a factor of 20 percent, a volume of approximately 1.12 million gallons would be required for equalization storage.

The amount of fire flow storage required, is based on recommedations of the Insurance Services Office (ISO), which determines needed fire flows for insurance rating classifications of buildings within the distribution system. Results of hydrant flow tests conducted by ISO in 1990 and more recently in 2002 indicated needed fire flows ranging from 500 gpm for residential areas to 7,000 gpm for commercial areas.

According to the DEP, municipalities are only required to provide up to a maximum fire flow of 3,500 gpm for a three-hour duration. Any additional fire flow required is typically the responsibility of the building owner. Therefore, based on a fire flow of 3,500 gpm at a duration of three hours, a volume of approximately 630,000 gallons would be required for fire protection *(3,500 gpm x 60 minutes/hour x 3 hours).*

Emergency Storage

Any storage provided within a tank beyond the volumes for equalization and fire flow storage is considered emergency storage and would be available for pipeline breaks, equipment failures, and other emergency situations. The volume required for emergency storage is a function of risk with respect to an interruption of supply.

DEP guidelines recommend that municipalities provide emergency storage equal to the average daily consumption if supply sources for a system are not equipped with sufficient standby power to meet this consumption during a power failure, or lack system redundancy with respect to pumps and/or pipelines. The previous 1989 report estimated the emergency storage volume based on this criteria which was appropriate considering the hydraulics of the existing water system at that time.

For this report, we have estimated the future emergency storage to be 25 percent of the average daily consumption. This will provide the City with some storage to offset the possible loss of supplies and/or future pumping facilities without interrupting service for several hours.

Adequacy Of Main Service Storage Facilities

Based on the criteria presented for determining future storage needs, the estimated future storage requirements for the City are shown in the Table 3-1.

TABLE 3-1
ESTIMATED FUTURE STORAGE REQUIREMENTS
MAIN SERVICE

	Volume Required (MG)	
Storage Item	**2005**	**2025**
Equalization	0.97	1.12
Fire	0.63	0.63
Emergency	0.81	0.93
Total	2.41	2.68

Under current operating conditions, with the continuous gravity feed from the Mountain Street and Ryan Reservoirs, sufficient water is available to meet the storage requirements of the City. As discussed above, upon construction of the new water filtration plant, the total combined storage volume for the Main Service system will be approximately five million gallons (MG), which includes the proposed clearwell/storage tank at the plant and the existing Turkey Hill tank. However, all of this storage volume cannot be considered “usable”.

Calculation of Equalization Storage

According to DEP Guidelines, equalization storage should be provided to customers under domestic system demand conditions at a minimum pressure of 35 psi (81 feet of hydraulic head). Thus, only the volume of water within a tank that will provide a pressure of 35 psi to the highest service elevation can be considered usable equalization storage.

Based on the data utilized to develop the computerized system model, none of the Turkey Hill tank’s volume can be considered available for equalization. According to the City, the new clearwell/storage tank’s entire volume being available for equalization storage.

Calculation of Fire Flow Storage

For fire flow storage, DEP Guidelines define usable fire storage as the volume of water within a storage tank that will provide a pressure of 20 psi (46 feet of hydraulic head) to the highest service elevation in the system. Based on its diameter and overflow elevation, approximately 347,000 gallons are available within the Turkey Hill tank as usable fire storage.

Assuming that the required equalization storage will be entirely met by the proposed clearwell/storage tank at the new treatment plant, approximately 56% of the total volume is available for fire protection.

- *It appears that the City will have sufficient storage capacity to meet the projected equalization, fire, and emergency storage volume.*
    - ***However, system redundancy and its impact on supply can also affect the available storage in the system, and need to be considered when evaluating storage.***

Additional Storage/System Redundancy for Maximum Day and Fire Flow

It is common practice to evaluate the adequacy of system storage together with supply to meet anticipated maximum day and fire flow demands with the largest pump or source of supply, out of service. With both transmission mains in operation, adequate supply is available to satisfy projected domestic and fire flow demands for the City's distribution system based on the capacities of the mains. However, without both transmision mains in service, there may be a concern with respect to water supply. From conversations with City staff, one of the mains has been recently taken out of service for an extended period of time to conduct repairs so it is not unreasonable to assume such an occurrence for planning.

The earlier 1989 study reported the capacity of one of the mains to be approximately 7.4 MGD which accounted for it being cleaned and lined in 1958. Based on the scenario of meeting the projected 2025 maximum day demand rate of 5.58 MGD in conjunction with the ISO fire flow requirement of 3500 gpm for three hours as established for the City, the total supply capacity required would be approximately 10.6 MGD. This is approximately 3.2 MGD greater than the capacity available through one of the mains, assuming that its capacity is still 7.4 MGD. For a demand duration of three hours, a required usable storage volume of approximately 403,200 gallons would be required within the distribution system to compensate for the noted lack of hydraulic capacity.

To supplement the transmission mains, the City also has two wells within the distribution system, which are currently operated on a minimum basis. From discusions with City staff, it is our understanding that these wells could potentially be used over a prolonged period of time to compenstate for the loss of one of the transmission mains. The wells have rated production capacities which would provide a combined capacity of approximately 1.9 MGD depending on the system hydraulics and characteristics of the wells. For a three hour fire flow event, these wells would supply an additional volume of approximately 234,000 gallons.

- *Considering the additional supply provided by the wells, the required usable storage volume that is to be provided under the noted demand scenario would be reduced to approximately 169,200 gallons.*

Additional Storage/System Redundancy During Peak Hour Demands

The amount of distribution storage required to meet peak hour demands in a water system should also be related to the maximum supply capacity of one of the mains. As disussed in Section 2, for the purposes of evaluating storage needs with respect to supply capacity, the projected peak hour demand has been estimated to be 1.5 times the maximum day rate. Based on the projected maximum day demand for the year 2025 of 5.58 MGD, the estimated peak hour demand is approximately 8.4 MGD which is 1.0 MGD greater than the available 7.4 MGD capacity of one of the mains. For a peak hour demand period of two hours, the required usable storage to offset the noted lack of capacity is approximately 84,000 gallons.

Coupled with the required usable storage volume of 169,200 previously estimated for the maximum day demand with fire flow scenario, the total usable storage required to address the loss of one of the transmission mains would be approximately 253,200 gallons. Considering the 347,000 gallons of available usable storage from the existing Turkey Hill Tank, the City would not need any additional usable storage volume within the distribution system.

- *Based on system redundancy, it appears that the City has sufficient storage to compensate for the loss of its major source of supply.*

System Storage Relative to System Needs and Hydraulics

Another important factor to be considered when evaluating storage is its location with respect to system needs and hydraulics. Based on the location of the new treatment plant clearwell/storage facility, only partial benefits to the system with respect to equalization and/or stabilization of pressure will be provided because of its distance from the point of major water usage, even with both transmission mains in service.

- *Ideally, storage should be located at the extremities of a distribution system opposite from supply sources.*

Locating storage at the extremities of the distribution system would provide a more equalized pressure distribution over the whole service area, and improve the coverage, or boundary of service from each source of supply and storage. In addition, to be more effective, storage should be located as close as possible to those service areas requiring high demand flows, preferably within the proximity of large diameter water mains capable of delivering stored water during peak demand and fire flow conditions.

- *Based on the criteria presented, Dewberry feels that the storage requirements for the City's water system should be more evenly balanced between the future treatment plant clearwell and another storage facility and/or facilities located within the distribution system.*

This approach will provide better pressure equalization for the system, and added operational flexibility and redundancy for meeting peak hour and fire flow demands.

As listed in Table 3-1, the City's future usable storage requirement for the year 2025 is estimated to be 2.68 MG. To provide a more balanced approach for system storage, and the additional storage with respect to system redundancy and supply as discussed above:

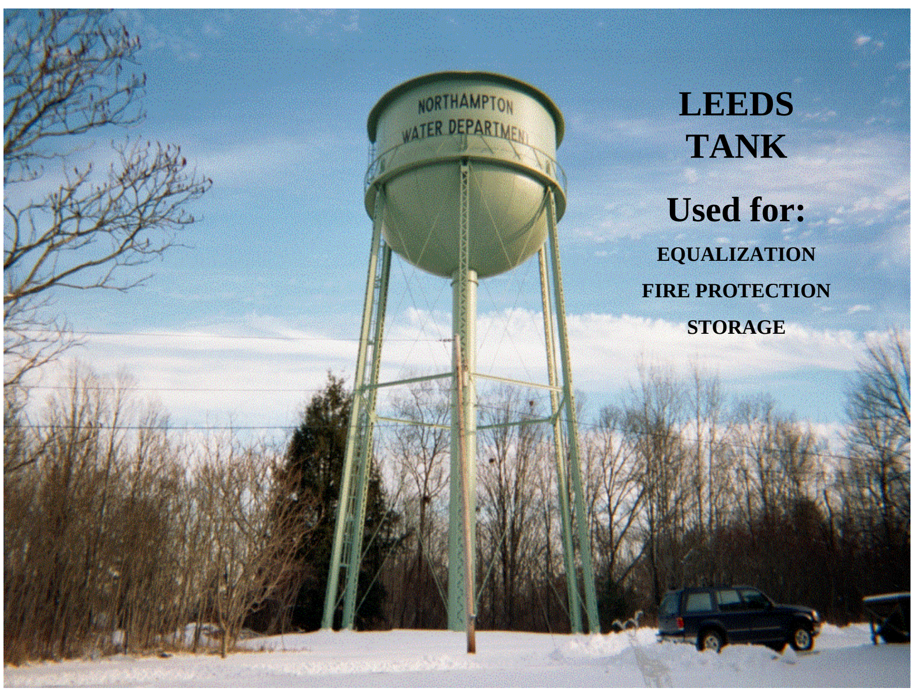
- *At least 1.0 MG of usable storage should be provided directly within the distribution system.*

One alternative to address the estimated storage needs is to raise the overflow elevation of the existing Turkey Hill tank. A detailed discussion on the hydraulics and impacts of this approach to the system is presented in Section 5.

Leeds Village High Pressure System Storage Requirements

The Leeds Village High Pressure System contains only one existing storage facility, an elevated tank off Audubon Road.

The Leeds Village High Pressure System is served via a pumping station, and not directly connected to the storage facilities of the Main Service system, therefore, storage requirements for the High Pressure System must be evaluated separately. The three components previously discussed were used to determine the required usable storage.



Equalization

For equalization, using a value of twenty-five percent of the maximum day demand for the High Pressure System (approximately six percent of total system maximum day demand), the required usable equalization storage for the year 2025 is approximately 84,000 gallons

Based on the data utilized to develop the computerized system model, the highest service elevation in the High Pressure System is approximately 460 feet NGVD which would require the volume allocated for equalization storage to be provided above an elevation of 541 feet

- *Since the overflow elevation for the Audubon tank is lower than the required elevation of 541 feet, none of the tank's volume can be considered available for equalization storage*.

Fire Protection

For fire protection, the maximum required fire flow for the High Pressure System, as determined by ISO in 1990, is 3,500 GPM for three hours at the Leeds Elementary School. This results in a required usable storage for fire protection of approximately 630,000 gallons. Since the only supply source, the booster pumping station, has no emergency power and relies solely on power from utilities, emergency storage equal to the average daily consumption would be required for the High Pressure System based on DEP guidelines.

For fire flow storage, with a maximum service elevation of 460 feet, the volume of water within the tank required for fire protection should be above an elevation of 506 feet to be considered usable.

- *Based on its dimension and overflow elevation, all of the tank's 200,000 gallons is available as usable fire storage.*

With respect to supply, under current operating conditions, with no fire pump, a total volume of 54,000 gallons would be available from one of the two domestic service pumps at the booster station for a three hour fire flow period.

It is our understanding that currently, to address the noted lack of fire protection, the fire department may utilize a pumper truck to draw water from the Leeds Reservoir if needed.

Emergency Storage

The volume of emergency storage required for the year 2025 is approximately 223,000 gallons. Therefore, the total usable storage required to meet the future needs of the High Pressure System is estimated to be 937,000 gallons.

- *Considering the available storage from the existing Audubon Tank, the High Pressure System would need an additional total usable storage of 683,000 gallons.*

Two alternatives to address the estimated storage deficit are:

- *To upgrade the existing booster pump station with a larger capacity fire pump and an emergency generator; or*

- *To provide a fire loop connected off the Main Service system to serve the Leeds Elementary School. A detailed discussion of this approach is presented in Section 5.*

SECTION IV – ADEQUACY OF THE EXISTING DISTRIBUTION SYSTEM

GENERAL

To properly serve its residents, a water distribution system must be able to meet demands during periods of peak consumption and provide adequate fire protection. Both peak demand conditions and fire flows are typically met from system storage reserves and not by relying on supply pumping.

The City's storage facilities have been assessed in the previous section with respect to storage volume requirements and usable storage available. This section of the report will evaluate the capability of the distribution system to deliver fire flows at adeqaute pressures for fire protection during maximum day demands. This demand condition is considered to be the maximum amount of water that a distribution system must realistically supply and has been established as a prime criterion for the evaluation of water distribution systems.

A hydraulic analysis was conducted utilizing the updated computerized distribution system model completed by Dewberry as an earlier task, and available hydrant flow test results to evaluate the distribution system's ability to meet the above demand condition.

RECOMMENDED FIRE FLOWS

The Insurance Services Office Commercial Risk Services Inc. (ISO), has established certain standards by which the adequacy of a public water system to provide fire protection can be rated. Fire flow requirements for a community are typically established for each type of development within a community. The required flow rate and duration of flow for each type of development are based on structural conditions, type of occupancy, and the congestion of buildings in the area under consideration.

The largest fire flow demands generally occur in the major business and industrial districts of a community. The ISO standards are used to set fire insurance rates within a community. In the planning and design of a waterworks system, it is considered good practice to adhere to these standards, not only to minimize fire insurance rates, but to reduce the risk of human casualties and loss of property resulting from fires.

Based on ISO guidelines, recommended fire flows are defined as:

> *The required flow rate from a point in the system while maintaining a minimum pressure of 20 psi at all points in the distribution system.*

- For one and two family residential areas, the ISO required fire flows range from 500 gpm to 1,500 gpm, depending on the spacing of the houses.

- For high-density residential, commercial, institutional, and industrial areas, the maximum required fire flow to be sustained by the distribution system is 3,500 gpm.

- Individual site requirements greater than 3,500 gpm, which might exceed the capacity of the distribution system, should be met through fire protection systems provided by the property owner.

The ISO has also established time duration requirements for which fire flows should be maintained to assess the adequacy of system storage. In general:

- Required fire flows up to 2,500 gpm should be maintained for two (2) hours; and

- Required fire flows up to the maximum 3,500 gpm should be maintianed for three hours.

These ISO fire flow duration requirements were used in the previous section to evaluate the adequacy of the City's storage systems to meet current and future storage needs.

HYDRANT FLOW TESTS

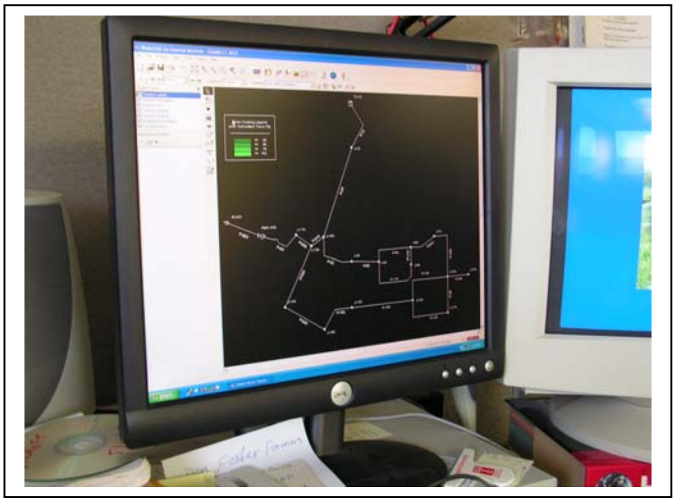
The ISO conducted hydrant flow tests in the City of Northampton to determine the water system's ability to provide adequate fire protection in November 1990 and again in September 2002.

- *It is apparent that portions of the existing distribution system are not capable of providing adequate fire protection.*
    - *It should be noted that improvements to the City's water system have been made since the 1990 testing including the installation of a new transmission main which has reduced the number of deficient areas as evident during the computer analysis of the system.*
    - *The City has conducted numerous hydrant flow tests, as recent as 2004, which reflect the impacts of the system improvements made. The results of these tests were used in conjunction with the ISO hydrant flow data to analyze the system and develop a balanced computer model.*
    - *Additional hydrant flow testing was conducted on the City's system on October 21, 2004 by Dewberry to further evaluate known problem areas and to collect needed data for the purpose of analyzing, adjusting and calibrating the existing model. These tests were conducted at night to minimize impacts to local residents.*

COMPUTER MODELING

The computerized system model updated with the WaterCAD software program was used to conduct hydraulic analyses of the distribution system. Various demand and operational scenarios were simulated with the model to evaluate impacts to the existing system and develop recommendations to alleviate deficiencies and meet future water needs. The existing computer model and associated database was created as part of the Water System Plan in 1989 with the KYPIPE software program. This computer model was based on a manually created schematic of the distribution system and provided a somewhat skeletonized representation of the actual water system.

The City recently began the process of converting this computer model into the WaterCAD hydraulic software created by Heastad Methods, Inc. As part of this study, Dewberry completed the population of the model database and integrated the new WaterCAD-based model into the City's GIS program. The intent was to provide the City with a calibrated computerized model, that is a true and accurate representation of the water system, which will serve as a much better tool for evaluating existing and future needs.



Location of system components and pipe lengths were automatically configured and calculated by the software during the creation of a map. Additional data that was necessary for modeling the water system was collected, tabulated, and manually input into the computer model.

Various sources were utilized to obtain the noted information for the computer model. Information and reports on material composition of pipes, year of installation, and diameter was provided by the City which was used to estimate the hydraulic capacity or roughness coefficient of the pipes in the system.

The roughness coefficient (C-value) for water main refers to the carrying capacity of the pipe which varies with a pipe's age and material of construction, as well as its diameter. For example, newer cement-lined ductile iron pipe has a smooth interior surface and tends to retain its original capacity for many years where as older unlined cast-iron pipe is prone to corrosion and the formation of turberculation over time. As a result, their carrying capacity tends to gradually diminish over time.

New water pipe prior to installation

Old water pipe removed from system

In addition, larger diameter mains tend to have higher carrying capacities than smaller diameter mains since larger mains typically transmit greater volumes of flow and are well looped which tends to prevent the buildup and accumulation of sediment and turberculation within the pipe's interior.

Water demands were estimated using the 2004 average day demand of 3.22 MGD as shown in Table 2-3 and assigned to junction nodes throughout the system. Large commercial, agricultural, and industrial users were first identified, and their individual demands, as determined from City meter records, were applied to the nearest node that best represents their actual locations within the system. A list of these large users along with their representative nodes are shown in Table 4-1.

The total large user demand was then subtracted from the average day demand. This remaining demand was then distributed over the nodes throughout the system, taking into account the population density and number of housing units at various locations along the pipe network.

HYDRAULIC ANALYSIS

As previously mentioned, hydrant flow tests have been conducted at various locations throughout the distribution system by ISO, the DPW's Water Division, and Dewberry. The results from the hydrant flow tests including static pressures, residual pressures, and flow were simulated in the computer model. Adjustments to the computerized hydraulic model were made until the results of the model simulations compared favorably to the hydraulic data collected during the field tests.

At this point, the hydraulic model was considered to be calibrated and adequately representative of the physical operating characteristics of the existing distribution system.

TABLE 4-1
2003 LARGE USERS

User	MG/Yr	% Usage 2002(1)	GPM 24 HRS	Address
Coca-Cola	117.59	9.55	223.73	45 Industrial Dr.
Pro Corp. – PMC	33.49	2.72	63.72	11 Nonotuck St.
VA Medical Center	22.30	1.81	42.43	421 North Main St.
Sunrise Care	7.44	0.60	14.16	548 Elm St.
Northampton Housing Authority	6.66	0.54	12.67	81 Conz St.
Packaging Corp. of America	6.49	0.53	12.35	0 Island Rd.
Hampshire County Jail	6.19	0.50	11.78	205 Rocky Hill Rd.
Old Way Leasing	5.90	0.48	11.23	23 Atwood Dr.
Cooley Dickinson Hospital	5.36(2)	0.44	10.20	30 Locust St.
Hampton Ct. C/O Carmen Nie	5.17	0.42	9.84	20 Hampton Dr.
Star Northampton Inc.	4.85	0.39	9.23	36 King St.
Northampton School Dept.	4.56	0.37	8.68	380 Elm St.
Wastewater Treatment	4.25	0.35	8.09	33 Hockanum St.
Smith College	4.17	0.34	7.93	0 Kensington St.
Perstorp Inc.	4.11	0.33	7.82	238 Nonotuck St.

(1) Percentages based on total consumption of 1,231,411,000 gallons in 2002.
(2) This usage was estimated from City billing records, prior to meters being installed.

After the calibration of the computerized hydraulic model, associated data to reflect estimated water demands through the year 2025 was input into the model. The computer model was subjected to various flow conditions to evaluate the adequacy of the distribution system to meet future water requirements and to identify problem areas and system deficiencies.

Improvements to the distribution system were then made in the model to evaluate their impacts and to develop recommendations for alleviating the noted deficiencies within the Main Service and Leeds Village High Pressure Systems. The computer model was also used to assess the operational alternative of creating a separate low pressure zone to reduce the high system pressures being experienced in the downtown area, and to assess the hydraulic impacts of raising the Turkey Hill tank as discussed in Section 5.

The overall results of the hydraulic analysis:

- *Indicate that the system is adequate under average day and maximum day demands;*

However:

- ***There are several areas in the system which are unable to provide the required fire flows as rated by the ISO, mainly due to the presence of undersized and/or unlined mains that serve these areas; and***

- ***The downtown portion of the system experiences pressures as high as 135 psi which exceeds the DEP recommended range of 35 psi to 110 psi for distribition systems.***

These extreme pressures can result in:

- Excessive leaking/unaccounted-for water;

- Water hammers; and

- System surges, leading to water main breaks.

Improvements will be required to provide adequate fire protection for those areas found to be deficient and to address the excessive system pressures. These will be discussed in more detail in Section 5.

Main Service System

The Main Service system is capable of meeting:

- Average day;
- Maximum day; and
- Peak hour demands.

However, under maximum day demands **with** imposed fire flows:

- *The system is not capable of delivering the required ISO fire flows at the minimum 20 psi pressure to several residential and commercial districts as determined from the computer model.*

Areas of concern include the following:

- Upper end of North King Street
- Bridge Road from Chestnut Street to Damon Road
- The Lower end of Mt. Tom Road
- Elm Street at Green Street
- The End of Westhampton Road at Glendale Road.

These areas of concern, listed above, are served by unlined and inadequately sized cast-iron mains which reportedly have low C-values and minimal carrying capacity. These mains are hydraulically incapable of delivering the fire flows while maintaining the minimum pressure of 20 psi required for adequate fire protection.

- *They should be cleaned and lined and/or replaced with larger transmission mains to better serve these areas.*

Another area of concern is the extreme system pressures maintained in the Main Service System. Due to the varying topography being served, pressures range from as low as 28 psi at the upper end of the system to as high as 135 psi in the lower lying downtown area. Fortunately, the higher pressures being served are primarily concentrated within the eastern section of the City and based on the physical characteristics of the system, can be isolated through installing pressure-reducing valves to the create a separate pressure zone. The creation of a such a zone is further discussed in Section 5.

Leeds Village High Pressure System

The Leeds Village High Pressure System is capable of meeting:

- Average day; and
- Maximum day demands.

However, under maximum day demands with imposed fire flows:

- ***The system is not capable of delivering the required ISO fire flow of 3,500 gpm at the minimum 20 psi pressure for the Leeds Elementary School, which is located on Florence Street.***
- ***In addition to the school, there are several other commercial businesses within the High Pressure System including Chartpak Industrial on Mulberry Street and Berkshire Cable on River Road.***
    - ***It is likely that the fire flow requirements for these businesses cannot be provided as well.***

The High Pressure System contains small unlined mains which restrict flow and are incapable of delivering the required fire flows to the school and other commercial users.

The existing booster pumping station is sized to provide domestic service only and is not equipped with fire pumps. In addition, as discussed in Section 3, the existing storage tank does not provide sufficient usable storage volumes for fire protection or equalization.

Alternatives to improve fire protection for the High Pressure System include:

- *Upgrading the existing booster pump station with larger capacity fire pumps; and/or*

- *Providing a fire service connection to the Main Service system to meet the fire flow requirements for the school.*

These and other upgrades to the system are further discussed in Section 5.

Water main construction

SECTION V – RECOMMENDED IMPROVEMENTS

GENERAL

The previous sections of this report have presented the existing conditions and analysis of the City's water system and have identified various deficiencies in meeting current and projected future water demands. This section of the report presents the recommended improvements to address these deficiencies based upon review of existing records, results of the hydraulic analysis conducted with the computer model, and from discussions with City personnel.

RECOMMENDED WATER STORAGE IMPROVEMENTS

The City's current reservoir supply system provides a significant amount of storage volume due to the direct connection with the distribution system.

With the construction of the new water filtration plant in Williamsburg, the required storage volume for the City's system will be provided primarily through the new clearwell. Even though the capacity of the new clearwell will be sufficient with respect to storage volume:

- *Its supply availability will rely solely on the hydraulic capacity of the existing dual transmission mains.*

Based on the hydraulic analysis conducted, with the newer transmission main out of service:

- *It was noted that insufficient capacity is available through the older transmission main to deliver the high flows required during peak hour demands, and provide adequate fire protection by itself.*

However, by utilizing the City's two well supplies to offset the loss of the newer transmission main, the total required capacity can almost be provided to meet the worst-case demand scenarios as imposed on the system.

Another concern with respect to the storage being provided by the new clearwell is its location in proximity to the distribution system. The significant distance between the clearwell and the high demand areas within the system will limit its effectiveness in adequately providing equalization.

To provide more effective storage and system redundancy, it was recommended that approximately 1.0 MG of additional usable storage be provided within the limits of the distribution system.

To accomplish this approach:

- *It is recommended that the existing Turkey Hill Tank be raised to an overflow elevation equal to at least the current system gradient.*

Increasing the overflow elevation of the tank will provide approximately 1,000,000 gallons of total usable storage at the far end of the system, and will allow the tank to properly fluctuate off the system thereby reducing concerns regarding stagnant water.

This will improve localized fire protection within the service area of the tank and provide better pressure equalization for the system.

Based on the analysis conducted, with a higher overflow elevation:

- *The Turkey Hill Tank is expected to turnover approximately every five to seven days, depending on system demands.*
  - *This is a typical rate of turnover for water storage tanks, and should be sufficient to avoid potential problems with stagnation and water quality, particularly when the new treatment facility comes on-line.*
  - *To further enhance the circulation of the tank, a tank mixing system consisting of an internal riser pipe with separate inlet and outlet assemblies is recommended as part of upgrading the tank. This system will draw water for system usage from the lower portion of the tank, and fill the tank from the system through the top portion of the tank, which will optimize tank circulation and further reduce the potential for stagnant water.*

As water quality regulations become more stringent, and changes with respect to treatment and system operations are made, it may be desirable in the future to increase the turnover rate for the Turkey Hill Tank.

One approach that the City could easily implement for this purpose:

- *Is to provide a control system at one of the PRV stations, designed to periodically throttle back flow from one of the transmission mains which would then allow the Turkey Hill Tank to fluctuate more frequently as needed.*
  - *This control scheme could be automated through the SCADA system at the new treatment facility.*

It should be noted that the recommended storage improvements presented herein are based on the fact that:

- *The City will continue to maintain and operate the two existing well supplies which, as noted previously, are required to offset the lack of storage redundancy within the distribution system upon loss of the one of the transmission mains.*

The results of the hydraulic analysis:

- *Confirm that one of the transmission mains alone cannot provide adequate supply for peak hour demands and fire flows without the wells in service, particularly within the downtown area, even with the added storage from raising the Turkey Hill Tank.*
    - *The Turkey Hill Tank is approximately four miles from the downtown area which is a considerable distance away.*
    - *Stored water within the tank cannot be efficiently delivered to this part of the distribution system due to hydraulic losses through the connecting pipelines.*
    - *If the well supplies are permanently taken off-line for any reason in the future, the City will need to consider providing up to 0.5 MG of additional storage within the distribution system, preferably in the downtown high demand area, to compensate for the loss of the well supplies.*

RECOMMENDED PIPELINE IMPROVEMENTS

As discussed in Section IV, results of fire flow testing conducted by the ISO indicates that several areas of the system have inadequate fire protection. From the computer modeling and analysis, these areas were noted to be served by older, unlined mains which have a reduced hydraulic capacity due to the buildup of tuberculation. Also, some areas were found to have undersized mains which exhibited high headlosses under peak demand and fire flows. The water main improvements recommended herein have been selected based upon the following criteria:

- Alleviate fire flow deficiencies;
- Increase water transmission; and
- Looping to eliminate dead ends and improve water quality

From discussions with City staff, some of the recommended pipeline improvements presented are currently being completed, or are planned to be completed in the near future. These improvements have been noted accordingly in the following tables.

Water Main Cleaning and Lining

There are a large number of older cast iron water mains which are suspected to be unlined. The tuberculated and pitted interior surfaces of unlined mains can promote problems such as discoloration, increased disinfection demand, and high pipeline head losses.

The Water Department maintains a list of water main installation dates and materials, as part of the City's GIS program, for a majority of the existing water mains. This information was utilized in the development of the computer model and subsequent analysis conducted to evaluate the distribution system. Table 5-1 presents the recommended water mains to be cleaned and lined based on providing adequate fire protection and eliminating possible restrictions due to high pipeline head losess.

TABLE 5-1
RECOMMENDED WATER MAIN CLEANING AND LINING[1]

Location	From	To	Size (Inches)	Length (Feet)
North King St.	Hatfield St.	Laurel Park.	10	5,000
Hatfield St.	North King St.	Cooke Ave.	10	1,600
Cooke Ave.	Hatfield St.	Bridge Rd.	10	1,200
Bridge Rd.	North Main St.	Industrial Dr.	12	13,250
King St.	Damon Rd.	Barrett St.	12	1,750
King St.	Barrett St.	Main St.	10	5,500
Pleasant St.	Holyoke St.	Wright St.	12	1,100
Wright St.	Pleasant St.	Conz St.	12	500
Conz St.	Wright St.	Pleasant St.	12	775
Pleasant St.	Conz St.	Atwood Dr.	12	3,000
Federal St.	Nonotuck St.	Washington Ave.	16	4,600
Washington Ave.	Federal St.	Dryads Green.	16	400
Dryads Green.	Washington Ave.	Paradise Rd.	16	1,300
Paradise Rd.	Dryads Green.	Elm St.	16	1,000
Elm St.	Paradise Rd.	College Lane.	16	520
College Lane.	Elm St.	Green St.	16	2,000
Earle St.[2]	Grove St.	the north	12	800
Grove St.	Chapel St.	Earle St.	10	2,500
Grove St.	Earle St.	South St.	12	1,000
Main St.	Pleasant St.	West St.	16	1,700
West St.	Main St.	Green St.	16	500

(1) The actual conditions of these water mains should be verified through coupons, or conducting C-value tests, prior to cleaning and lining.
(2) This main is scheduled for replacement as part of State Hospital build-out project.

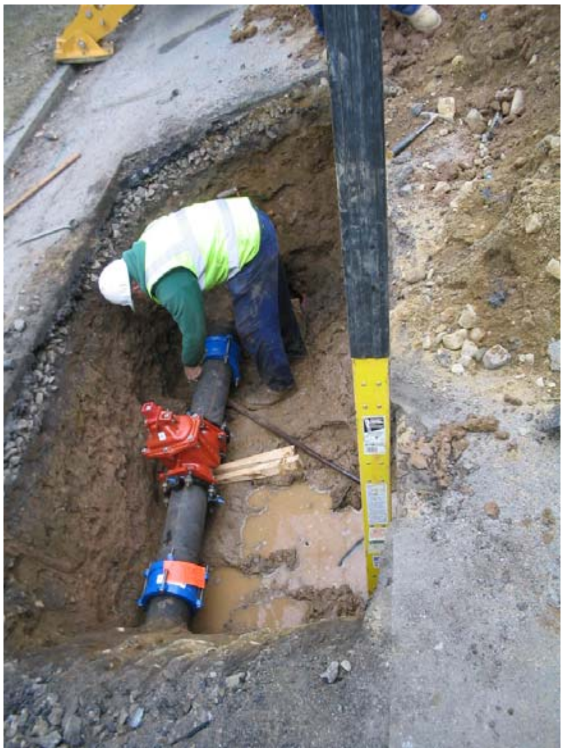
A majority of these pipelines are larger-sized unlined transmission mains which were noted to have apparent low C-values during the balancing of the computer model. As noted in Section 4, the C-values for these mains were initially determined based on pipeline age and material, and further adjusted in the model to simulate the results of hydrant flow tests to develop a calibrated model for predicting future needs.

The model cannot differentiate hydraulic losses that are caused by either low C-values or other possible restrictions within a pipeline, such as partially closed valves. Both conditions can produce similar results with respect to flows and pressures, particularly over long pipeline lengths.

- *Prior to scheduling these mains for cleaning and lining, field verification should be made, either from taking a coupon or conducting C-value tests in the field, to determine their actual physical condition and if the main, indeed, needs to be cleaned and lined.*

Water Main Replacement

Pipelines have been recommended for replacement in areas where inadequate fire flows were noted or where the evaluation of the distribution system identified the need for a larger main to improve system hydraulics. Also, there are portions of the distribution system which consist of dead-end mains and are subject to inadequate flows and poor water quality. Table 5-2 presents the water mains recommended to be replaced to provide a more efficient flow of water throughout the distribution system and eliminate dead ends.



Water Main Replacement

TABLE 5-2
RECOMMENDED WATER MAIN REPLACEMENT

Location	From	To	Present Size (Inches)	Proposed Size (Inches)	Length (Feet)
REPLACEMENT WATER MAIN					
Westhampton Road(1)	Glendale Road	Florence Road	8	12	14,000
Rocky Hill Road (1)	Florence Road	Old Wilson Road	8	12	3,000
Glendale Road	Westhampton Road	South on Glendale Road	6	8	1,800
Burts Pit Road	Redford Drive	Rural Lane	8	12	400
West Farms Road	Ryan Road	Westhampton Road	8	12	3,900
Ryan Road	Florence Road	Clark Street	10	12	1,600
Coles Meadow Road	North King Street	Marian Street	8	12	400
South Street	South Park Terrace	Charles Street	6	8	1,000
Earle Street (2)	West Street	South on Earle Street	6	12	800
NEW WATER MAIN					
Damon Rd.	Old Water St.	Bridge St.	N/A	12	1,400.(3)

(1) This main is scheduled for replacement as part of the MHD reconstruction project.
(2) This main is scheduled for replacement as part of the State Hospital build-out project.
(3) Length as determined by the City – completed September 2005.

According to the City, the Massachusetts Highway Department (MA Highway) is planning to reconstruct Westhampton Road (Rt. 66) within the next couple of years. Part of that reconstruction will include replacing the existing 8-inch cast iron main within the roadway that extends from Old Wilson Road to Glendale Road. This pipe has been recommended for replacement as shown above in Table 5-2. It is our understanding that the size of the replacement main is proposed at this time to be 8-inches.

As shown in Table 5-2, Dewberry has recommended that a 12-inch main be provided for several reasons:

- *First, this water main is one of the cross-city mains along with the 12-inch main in Ryan Road that serves the southwest portion of the system, including the Turkey Hill Tank.*
    - *Coupled with the recommended improvements on West Farms Road and Ryan Road, a 12-inch main in Westhampton Road will provide an important redundant link between the downtown area and the Turkey Hill Tank, in addition to creating an improved transmission loop for the existing system.*
- *Secondly, the results of the computer analysis indicates that a 12-inch main would greatly improve fire protection for the existing residents along Westhampton Road and on Glendale Road, which currently is inadequate.*
- *Thirdly, the inherent capacity of a 12-inch main would be more beneficial for the operation of the Turkey Hill Tank once it is raised as recommended.*
- *Finally, based on its overall length and physical location, this pipeline will function more like a transmission main for this section of the system as opposed to a service main, and therefore, its diameter should really be no smaller than 12-inches.*

Miscellaneous Water Main Improvements

According to City records, there are a number of 8-inch diameter and smaller unlined water mains scattered throughout the distribution system. These unlined mains can lead to a reduction in water quality, plugged servcies and produce flow restrictions in the system.

It is recommended that the City:

- *Develop a continuing pipeline improvements program to replace and/or clean and line these mains.*
    - *This will improve water transmission and water quality throughout the system, as well as localized fire flows.*
    - *Cleaning and lining should restore the carrying capacity of these mains to a level almost equal to their original capacity, thus increasing the useful life of these mains.*
    - *It is typically less expensive to replace mains 6-inches or less than to clean and line them. However, there are conditions where replacement would be difficult due to the proximity of other mains or utilities and cleaning and lining would be a better alternative.*

When improving or upgrading the distribution system, the proper size selection and location of water mains and the manner which they are incorporated into the system are important factors in providing adequate flows and pressures. As a rule of thumb:

- *Any water main that extends up to 1,000 feet in length without a cross connection should have a minimum diameter of 8-inches.*
- *For lengths less than 500 feet, the minimum pipe diameter may be reduced to six-inches if the water main is used to complete a water main loop and the required fire flow is minimal.*
- *For pipeline lengths greater than 1,000 feet that have no cross connections, the minimum pipe diameter should be 12-inches.*

Wherever possible:

- *Dead ends should be eliminated by looping or interconnection; and*
- *All water mains should be cross-connected at reasonable intervals.*
- *In addition, the system should not contain any "bottlenecks" in which a smaller water main is the sole means of transporting water between larger mains.*

A review of the distribution system map shows that there are several short segments of smaller unlined mains which are situated between larger mains. Also, based on the recommended water main replacements, other similar short segments will be created.

- *These sections of main should be replaced with mains equal in size to the connected main to eliminate possible flow restrictions and/or "bottlenecks. These segments include:*
    - *Replace 400 feet of 8-inch main in Burt's Pit Road with 12-inch main*
    - *Replace 1,250 feet of 6-inch main in North Street with 8-inch main*
    - *Replace 1,600 feet of 10-inch main in Ryan Road with 12-inch main*

RESTRUCTURING OF MAIN SERVICE SYSTEM

As mentioned in Section 4, the lower lying downtown area of the City served by the Main Service system is under extreme system pressures, as high as 135 psi, based on the service elevations. Although no regulation has been established:

- It is generally accepted that pressures at street level exceeding 110 psi are considered excessive.

Such pressures can increase leakage and breakage of water mains and services, and require a higher level of maintenance. The effects of water hammers are also more pronounced at higher system pressures.

The City has historically experienced a high incident of breaks in this part of the system. A review of the City's water system indicates that the lower service elevations are concentrated within one particular section of the system.

- *A separate pressure zone could be created by installing pressure-reducing valves (PRVs) at critical locations which will isolate the section and allow the system pressures to be reduced to a more practical range. Based on the results of the computer analyses conducted to evaluate this alternative, it is recommended to install four PRV stations.*

Each station should include two PRVs:

- One sized for domestic service; and
- One sized for fire flows as well as by-pass piping.

In order to restructure the Main Service system as recommended, several water main improvements will need to be completed. Table 5-3 summarizes the improvements for creating the recommended Low Pressure Service System. The creation of the recommended Low Pressure system does not impact the effectiveness of the other recommended system improvements, and can be completed independently or in conjunction with other system improvements.

TABLE 5-3
RECOMMENDED CREATION OF LOW PRESSURE ZONE

Location	From	To	Size (Inches)	Length (Feet)
NEW WATER MAIN				
Liberty Street	Lexington Avenue	Warner Street	8	800
Warner Street	Federal Street	Maplewood Terrace	8	2,300
Maplewood Terrace	Hinckley Street	Warner Street	8	1,400
Hinckley Street	Maplewood Terrace	Nonotuck Street	8	700

In addition to the extreme system pressures experienced within the Main Service system, there are several areas which, due to their high service elevation, are below or barely at the recommended minimum system pressure of 35 psi under normal demand conditions.

Based on the computer analyses, it is recommended that:

- *The City encourage private/owner installation of individual booster pumps to existing services above 340 feet.*

Another approach to further improve pressures throughout the system:

- *Is to raise the current hydraulic gradient of the Main Service System.*
  - *This will be possible with the creation of the recommended Low Service System and the construction of the new water filtration plant.*
  - *Based on the reported operating ranges for the water treatment plant clearwell, the current gradient maintained in the Main Service system could be increased by 10 to 15 feet, or approximately 5 psi.*
  - *This increase in pressure will improve flows into the higher elevated areas and provide additional fire protection for the Main Service System.*

To increase the gradient of the Main Service system, additional improvements will be needed for the Turkey Hill Tank. As previously discussed:

- *It was recommended to raise the overflow elevation of the tank to the current system gradient to provide more usable storage and allow the tank to properly fluctuate off the system.*
  - *Raising the current gradient by 10 to 15 feet as proposed will result in the Turkey Hill tank being hydraulically isolated again from the system.*

To allow the City the flexibility to increase the Main Service system gradient, Dewberry recommends:

- *Raising this tank further to an overflow elevation which is 40 feet higher than its current overflow elevation.*
  - *Tank shells come in 8-foot increments and adding tank height by a factor of 8 is typically more cost-effective. With respect to storage volumes, operating the tank at a 40 foot higher gradient will provide an additional 250,000 gallons of usable storage within this section of the system*

The only concern that needs to be considered with raising the operating gradient of the Main Service system is the impact to the older existing transmission mains within the City's system including:

- *The older transmission main that extends from Williamsburg into the Leeds Service area.*
- *The main that extends from Leeds to Spring Street, and to Elm Street.*
- *The 16-inch main that extends from Leeds, into North Main Street and eventually Locust Street.*

These mains are over 100 years old and consist of lead-caulked joints which are prone to leaking.

Any increase in system pressure should be done gradually to minimize breakage and allow these mains to slowly adjust. Still, there could be incidents of water main breaks and repairs. It is recommended that:

- *Prior to increasing the hydraulic gradient of the Main Service System, the City conduct an investigation of the valves for these mains to identify which valves are operational and which valves should be replaced to isolate the mains for emergency repairs as needed*
    - *Additional valves and cross-connections may need to be installed to assist in isolating certain sections.*

RECOMMENDED IMPROVEMENTS TO LEEDS VILLAGE HIGH PRESSURE SYSTEM

As with the Main Service system, there are areas of the Leeds Village High Pressure System which cannot be provided with the recommended minimum system pressure of 35 psi from the overflow elevation of the Audubon Tank due to their service elevations, particularly along the upper portion of Audubon Road. These higher elevations are also responsible for the equalization storage deficit noted in Section 3. Based on the computer analyses, it is recommended that:

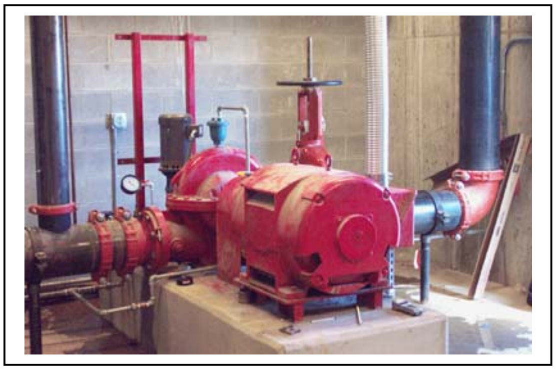
- *The City encourage the installation of individual booster pumps to existing services above 440 feet.*
    - *This recommendation will improve system operations and address the equalization storage deficiency.*

As previously discussed, the Leeds Village High Pressure System cannot provide adequate fire protection, primarily due to the ISO fire flow of 3,500 gpm needed for the Leeds Elementary School located on Florence Street. This system is primarily designed for residential usage and demands, consisting of only small unlined mains, which are not adequate for delivering the required fire flow to the school.

In addition, both the existing booster pumping station and storage tank are not sized to meet such a demand as needed for the school. Also, there are other commercial establishments within the system including Chartpak Industrial and Berkshire Cable, which require higher flows for fire protection.

Currently, it is our understanding that the City's fire department may address the noted supply deficiency by utilizing the Leeds Reservior to draw/pump additional supply for fire protection when needed.

One alternative to address the estimated storage deficit discussed in Section 3, and provide a more reliable means of fire protection for the system is to upgrade the existing booster pump station with:



Larger capacity fire pumps; *and* *An emergency generator*

These two items will greatly reduce the need for emergency storage and alleviate a portion of the storage deficit for the High Pressure System.

Another consideration to meet the fire flow requirements for the Leeds Elementary School is:

- *To extend a water main from the Main Service system up to the School site to provide a fire service loop including hydrants.*
    - *Based on the location of the School and its proximity to the Main Service system, this connection would be physically feasible from the 16-inch main either at Main Street, or towards the end of Florence Street.*
    - *A connection to the main on Haydenville Road is also possible, but this would require a greater length of water main, and easements to cross private property.*

This fire service connection will greatly reduce the storage deficit for the High Pressure System as discussed in Section 3, and will provide the needed fire flows for the school without having to conduct significant upgrades to the existing booster station and storage tank.

It is therefore recommended that:

- *The City include this fire loop connection to the 16-inch main as part of its improvement program.*

There are also two other known commercial establishments that need to be addressed with respect to fire protection including Chartpak Industrial on Mulberry Street and Berkshire Cable on River Road. Both of these sites are served by small existing mains.

One alternative is to install a large capacity fire pump at the existing booster pump station as stated above. Another consideration is to utilize the existing Main Service system to provide the needed fire flows similar to the school site. The existing transmisson main that enters the Leeds Village High Pressure System parallels the two smaller mains.

- *Hydrants could be installed on the transmission main near each of the sites to allow the Fire Department to draw directly from the Main Service system to provide the needed fire protection.*
    - *This is a relatively low cost solution and will eliminate the need to provide a large capacity fire pump at the existing pumping station.*
- *It is therefore recommended to install these hydrants on the transmission main at the required locations.*
- *It is also recommended to provide standby power for the existing booster pump station.*
    - *This will further reduce the estimated emergency storage deficit and provide a more reliable source of supply for the system.*
- *The need for providing a larger capacity fire pump for the existing booster pump station should be re-evaluated based on system needs with respect to growth.*

According to City records, the connecting main for the Audubon Tank is undersized for servicing a tank, and reduces the ability of the tank to provide equalization and fire protection. To allow efficient use of this storage tank, it is recommended:

- *To replace this entire main from the tank to Audubon Road with a new 12-inch main to provide sufficient capacity.*

As with the Main Service System, there are a number of older, smaller, unlined water mains within the High Pressure System. These unlined mains can lead to a reduction in water quality and produce flow restrictions in the system.

- *It is recommended that the City should include these mains as part of the recommended continuing program to replace and/or clean and line older and undersized mains.*

SECTION VI – PHASED CAPITAL IMPROVEMENTS

GENERAL

In the previous section, various improvements to the City's distribution system have been recommended to address deficiencies with respect to providing adequate fire protection and improving the transmission of flow through the system as determined from the hydraulic analysis. In order to assist the City of Northampton in implementing these improvements with consideration to available funding, the recommended improvements to the distribution system have been prioritized and are presented in this section as a phased capital improvement program.

Estimated costs presented in the following tables are total project costs and include:

- Construction;
- Engineering; and
- Contingencies.

Construction costs were developed in part using recent construction cost data for new water mains, water main cleaning and lining, pumping stations, water storage tanks and appurtenances. Other sources include the latest Means "Building Construction Cost Data" publication and manufacturers' quotes. These costs have been updated to reflect the March 2005 Boston ENR construction cost index.

The estimated costs do not include:

- Land acquisition;
- Right-of-way procurement;
- Permitting; and
- Legal fees.

CAPITAL IMPROVEMENTS

The recommended improvements for the City's water distribution system have been tabulated into the following three categories based on the City's immediate deficiencies, estimated needs, and benefit to the system.

- Initial System Improvements
- Phased Pipeline Improvements
- Main Service System Restructuring Improvements

The initial system improvements presented in Table 6-1 address immediate deficiencies with respect to system operations and fire protection, and should be considered the highest priority for implementation.

- ***The total cost for these improvements is $1,650,000.***

The phased pipeline improvements were developed to address current and projected deficiencies with respect to fire protection, hydraulic capacity, and transmission of flow as determined from the computer modeling conducted.

TABLE 6-1
INITIAL SYSTEM IMPROVEMENTS COST

Description of Improvement	Size (Inches)	Length (Feet)	Cost[1]
Turkey Hill Tank Improvements			
Upgrade Turkey Hill Tank Foundation			$375,000
Raise and paint entire Turkey Hill Tank			$750,000
Install internal tank mixing system			$90,000
Subtotal			**$1,215,000**
Leeds Village High Pressure System Improvements			
Installation of new emergency generator to existing booster station			$60,000
New fire service connection for Leeds Elementary School (off 16-inch main in Main Service)	12	2,000	$300,000
Replace 8" Audubon Tank connection with 12" main	12	500	$75,000
Subtotal			**$435,000**
Total – Initial System Improvements			**$1,650,000**

(1) Costs do not include land acquisition and legal fees.

A summary of the phased pipeline improvements is presented in Table 6-2.

Phase I pipeline improvements eliminate the most serious fire flow deficiencies in the existing distribution system and should be implemented over the next 5 years in conjunction with the initial system improvements described above.

- ***The total cost for these improvements is $7,169,000.***

TABLE 6-2
PIPELINE IMPROVEMENTS COST

Location	From	To	Size (Inches)	Length (Feet)	Cost[1]
Phase I (2005 - 2010)					
New Water Main / Replacement					
Westhampton Rd.	Glendale Rd.	Florence Rd.	12	14,000	$2,450,000[3]
Rocky Hill Rd.	Florence Rd.	Old Wilson Rd.	12	3,000	$525,000
Coles Meadow Rd.	North King St.	Marian St.	12	400	$70,000
Glendale Rd.	Westhampton Rd.	the south	8	1,800	$270,000
West Farms Rd.	Westhampton Rd.	Ryan Rd.	12	3,900	$683,000
Water Main Cleaning and Lining[2]					
North King St.	Hatfield St.	Laurel Pk.	10	5,000	$600,000
Hatfield St.	North King St.	Cooke Ave.	10	1,600	$192,000
Cooke Ave.	Hatfield St.	Bridge Rd.	10	1,200	$144,000
Bridge Rd.	North Main St.	Industrial Dr.	12	13,250	$1,590,000
Pleasant St.	Holyoke St.	Wright St.	12	1,100	$132,000
Wright St.	Pleasant St.	Conz St.	12	500	$60,000
Conz St.	Wright St.	Pleasant St.	12	775	$93,000
Pleasant St.	Conz St.	Atwood Dr.	12	3,000	$360,000
Subtotal – Phase I					**$7,169,000**

Phase II pipeline improvements address moderate deficiencies in the existing distribution system and should be implemented within the next 5 to 10 years.

- ***The total cost for these improvements is $3,204,000.***

Location	From	To	Size (Inches)	Length (Feet)	Cost[1]
Phase II (2010 - 2015)					
New Water Main / Replacement					
South Street	South Park Terrace	Charles St.	8	1,000	$150,000
Earle Street	West St.	West Street to the south.	12	800	$140,000
Water Main Cleaning and Lining[2]					
King St.	Damon Rd.	Barrett St.	12	1,750	$210,000
King St.	Barrett St.	Main St.	10	5,500	$660,000
Grove St.	Chapel St.	Earle St.	10	2,500	$300,000
Grove St.	Earle St.	South St.	12	1,000	$120,000
Main St.	Pleasant St.	West St.	16	1,700	$230,000
West St.	Main St.	Green St.	16	500	$68,000
Federal St.	Nonotuck St.	Washington Ave.	16	4,600	$621,000
Washington Ave.	Federal St.	Dryads Grn.	16	400	$54,000
Dryads Grn.	Washington Ave.	Paradise Rd.	16	1,300	$176,000
Paradise Rd.	Dryads Grn.	Elm St.	16	1,000	$135,000
Elm St.	Paradise Rd.	College Ln.	16	520	$70,000
	Elm St.	Green St.	16	2,000	$270,000
Subtotal – Phase II					**$3,204,000**

Phase III pipeline improvements address less critical deficiencies, eliminate noted restrictions or "bottlenecks" within the system and provide additional system reinforcement. These improvements can be implemented either after, in conjunction with the completion of the two previous phases, or as part of the continuous pipeline improvements program recommended to address the large quantity of older unlined 8-inch and 6-inch mains.

- ***The total cost for these improvements is $809,000.***

Location	From	To	Size (Inches)	Length (Feet)	Cost(1)
Phase III (2015 - 2025)					
New Water Main / Replacement					
Ryan Rd.	Florence Rd.	Clark St.	12	1,600	$280,000
Burts Pit Rd.	Redford Dr.	Rural Ln.	12	400	$70,000
Damon Rd.	Old Water St.	Bridge St.	12	1,000	$175,000
North St.	Bates St.	Orchard St.	8	1,250	$188,000
Water Main Cleaning and Lining(2)					
Earle St.	Grove St.	the North	12	800	$96,000
Subtotal – Phase III					**$809,000**
Total – Phase I, II, & III Pipeline Improvements					**$11,182,000**

(1) Costs do not include land acquisition and legal fees.
(2) Prior to cleaning and lining, C-value tests should be conducted or coupons taken to confirm condition of pipe.
(3) Some of the cost for this main may be carried as part of the road reconstruction project being completed by the MHD.

The restructuring of the Main Service system to create a Low Pressure Zone is recommended to address the extreme system pressures within the low lying areas of the City and reduce operations and maintenance costs associated with water main breaks and leakage.

As an added benefit, this new Low Pressure Zone will allow the City to increase the current operating gradient of the Main Service system including the Turkey Hill Tank which will improve system pressures to the higher elevated areas and provide additional storage volume. This restructuring and subsequent adjustment will provide a more balanced distribution system by minimizing the high and lows.

- ***The total cost for these improvements is $1,230,000.***

A summary of the restructuring improvements is presented in Table 6-3. It should be noted that the recommended restructuring is not a pre-requisite for the previous improvements, and does not have any impact on their effectiveness. **The City can implement the system restructuring improvements as funds become available.**

TABLE 6-3
MAIN SERVICE SYSTEM RESTRUCTURING IMPROVEMENTS COST

Location	From	To	Size (Inches)	Length (Feet)	Cost(1)
Creation of New Low Service Area					
Liberty St.	Lexington Ave.	Warner St.	8	800	$120,000
Warner St.	Federal St.	Maplewood Terr.	8	2,300	$345,000
Maplewood Terr.	Hinckley St.	Warner St.	8	1,400	$210,000
Hinckley St.	Maplewood Terr.	Nonotuck St.	8	700	$105,000
Prospect St. PRV (No. 6)			12	N/A	$120,000
Bridge Rd. PRV (No. 7)			10	N/A	$110,000
Rt. 66 PRV (No. 8)			10	N/A	$110,000
Nonotuck St. PRV (No. 9)			10	N/A	$110,000
Total – Main Service Restructuring Improvements					**$1,230,000**

(1) Costs do not include land acquisition and legal fees.